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PETROLOGICAL ABSTRACTS AND REVIEWS

EDITED BY ALBERT JOHANNSEN

CAMPBELL, ROBERT. "Preliminary Note on the Geology of Southeast Kincardineshire," *Geol. Mag.*, VIII (1911), 63–69.

In this paper the author presents the salient points of his rather important studies in this very interesting region. Extending about 3,500 feet southeast from Garron Point is a series of crushed green igneous rocks with intercalated black shales, jaspers, and cherts; and in the shales a remarkable suite of fossils has been found, tending to show that these rocks are of Upper Cambrian age. This series is bounded on the north by an overthrust fault, probably a continuation of the great Highland fault. Resting unconformably upon them to the southeast are 3,860 feet of Upper Silurian (Downtonian) rocks, chiefly sandstones and shales, with volcanic conglomerates and tuffs, and with a basement breccia 200 feet thick. The latter is largely composed of fragments of the underlying Upper Cambian rocks. In one of the sandstone and shale members of this series eurypterids and plant remains were found, and from one stratum an excellent collection of fishes was made. Overlying this series conformably, is the Lower Old Red Sandstone, and above this the Upper Old Red, while still later quartz dolerite dikes are frequently found.

It will be noted from the foregoing brief summary that aside from the detailed mapping several important reversals of the current classification have been made. It has always hitherto been thought that the great Highland fault formed the boundary between the Upper Cambrian and the overlying series and that the basement breccia of the latter was a fault breccia. Again, the 3,860 feet of the Upper Silurian had been previously considered part of the Lower Old Red Sandstone. Finally, the abundance of volcanic material in both of these formations indicates that volcanoes must have been active in this region in pre-Downtonian times, although Geikie had placed the initial outburst at a considerably later date.

G. S. ROGERS

DAY, A. L., AND SOSMAN, R. B. "The Melting Points of Minerals in the Light of Recent Investigations on the Gas Thermometer," *Amer. Jour. Sci.*, XXXI (1911), 341–49.

The determination of a new thermometer scale (described in a previous article) was based on investigations on the gas thermometer, which resulted in the attainment of a greater accuracy between 400° and 1,150°, and the extension of these temperatures by the extrapolated curve to 1,550° with an absolute accuracy of 2° at that temperature. Upon the more accurate data thus afforded the melting and inversion points of a number of minerals have been reinterpreted, and are here given. The tables are prefaced by certain definitions: thus, melting-point is defined as the point at which a mineral changes from a crystalline to an amorphous (liquid) state; inversion point as that at which it passes from one crystalline state to another; and the difference between the melting interval of slow melting pure compounds, such as quartz, and of mixtures of solid solutions, such as plagioclase, is discussed.

G. S. ROGERS

DEWEY, HENRY, AND FLETT, JOHN SMITH. "On Some British Pillow-Lavas and the Rocks Associated with Them," *Geol. Mag.*, VIII (May, 1911), 202–9; (June, 1911), 241–48.

The basic submarine lava flows form an important series among the Paleozoic igneous rocks of Great Britain, appearing in the pre-Cambrian and in all the Paleozoic systems except the Upper Silurian and the Permian. In most cases they show more or less of a pillow structure, are as a rule very much decomposed, and are characterized by feldspars rich in soda. The name spilite is generally applied. Under this name is described a rock of variable texture, of which the chief components are a soda-rich feldspar, pale brown augite, in some cases remains of olivine, and a fair amount of glassy base which is now wholly devitrified. The feldspar, especially in the more decomposed specimens, is albite and appears peculiarly fresh. From this, and other evidence, the authors argue that much of the albite is secondary and that it probably belongs to a pneumatolytic phase immediately following the extrusion. Associated with the spilites are intrusive rocks of a great variety of types—picrite, diabase, minervite, quartz diabase, heratophyre, quartz keratophyte, soda felsite, and albite granite—ranging from ultrabasic to acid in composition.

Accepting as established the division of the eruptive rocks into two great suites, the Atlantic and the Pacific, the authors would add to these another, the spilitic suite. This association of rocks is characteristic of regions which have undergone long-continued and gentle subsidence with no important folding. They belong to a natural family that can be clearly distinguished from the Atlantic and Pacific suites.

The constant association of adinoles (albitized shales) with the albitized igneous rocks furnishes a strong confirmation of the theory that there was a great addition of soda after the consolidation of the igneous rocks through the agency of magmatic waters.

E. R. LLOYD

JOHNSTON, J., AND ADAMS, L. H. "Influence of Pressure on the Melting-Points of Certain Metals," *Amer. Jour. Sci.*, XXXI (1911), 501–17.

The paper describes at considerable length a highly efficient apparatus for measuring melting-points with an accuracy of five atmospheres and of .02°. Pressures up to 2,000 atmospheres may be produced, and are transmitted by a high-boiling paraffin oil, the use of this agent enjoining a temperature of 400° as a maximum. The change of pressure of the melting-points of the only four metals melting below 400°, viz., tin, bismuth, lead, and cadmium are given; it was found to be a linear function of the pressure. The latent heat and volume change on melting of these four metals is also computed.

G. S. ROGERS

KRAUS, EDWARD H. "A New Jolly Balance," *Amer. Jour. Sci.*, XXXI (1911), 561–63.

The new features of this balance reduce the number of readings necessary for the determination of specific gravity and record the elongation of the spiral spring so that verification of the readings is possible.

HAROLD E. CULVER

MILCH, L. "Die heutigen Ansichten über Wesen und Enstehung der kristallinen Schiefer." *Geologische Rundschau*, Band I, Hefte 3 u. 4, pp. 36–58.

L. Milch aims at an impartial presentation of the views of various investigators on the nature and origin of the crystalline schists, with a bibliography of the most important papers.

He points out that two of the fundamental problems of the origin of crystalline schists are now settled, viz., the source of the crystalline schists, and their relation to time. They have developed from both sedimentary and igneous rocks in various periods, and are not the result of conditions peculiar to the Archean, as formerly supposed. Opinions are still divided, however, on the processes of schist development. These diverse views can be grouped under two heads: (I) those which ascribe the origin of schists to processes independent of the agency of igneous rocks; (II) those which regard the agency of igneous rocks as controlling.

I. The origin of crystalline schists without the agency of igneous rocks.

a) *High temperature of the earth's interior.*—Hutton and Lyell emphasized the alteration of normal sediments into schists through fusion and recrystallization effected by the high temperature of the earth's interior. This view and the experiments of Daubrie on the alteration of minerals by superheated water, formed the basis of Gümbel's diagenesis (1868), the alteration of mechanical sediments into crystalline schists by superheated waters.

b) *Hydrochemical metamorphism.*—Bischof and others interpreted the gradation between clay, slate, mica schist, and gneisses as resulting from the chemical action of percolating waters.

c) *Dynamic metamorphism.*—The fact that schists appear in areas of folded younger rocks led Lossen (1867) to assume that schists are sediments which have been recrystallized through moisture and pressure. Later Rosenbusch (1889, 1891) asserted that the crystalline schists include both igneous and sedimentary rocks which have been altered by geodynamic processes. In 1892 F. Becke concluded that there are two types of dynamic metamorphism. One of deeper zones is effected by recrystallization and resembles contact metamorphism by granites; that of shallow depths involves granulation and is like propylitization in its chemical effect.

In 1894 L. Milch argued that recrystallization could not be effected by pressure alone but must be traced to water heated or superheated by pressure, and that therefore pressure from load would have the same effect as pressure from crustal shortening, and thus differentiated. *Belastungs* and *Dislokations*—metamorphism. L. Milch, (1899), T. J. Sederholm (1891), and Lepsius concluded, independently, that rocks are chemically altered by pressure and percolating solutions combined.

Pressure produces secondary parallel structure (schistosity) by granulation of the original particles, by rotation of platy or columnar particles, so that their major dimensions lie in a plane normal to the pressure, and by recrystallization. According to A. Heim, rocks which are subjected to pressures far in excess of their strength are in a condition of latent plasticity (1878). In great depths, where stresses are transmitted equally in all directions, rock particles are under hydrostatic pressure, and therefore are deformed without fracture. Where deformation takes place without fracture, shearing on gliding planes as shown by O. Mügge and the increase in plasticity of crystals with rise of temperature as shown by L. Milch on halite are very important.

R. Brauns pointed out in 1896 that, wherever pressure, heat, and hot water act on a rock, alterations in the rock take place until equilibrium is reached.

In 1898 Van Hise divided the earth into a zone of fracture and a zone of flow. The crystalline schists develop in the latter, recrystallization and mineral parallelism being effected by water which causes the transfer of material by solution and deposition from areas of maximum pressure toward areas of minimum pressure. Van Hise also divided the earth's crust into two physical chemical zones, the upper characterized by reactions which liberate heat and the lower by reactions which absorb heat.

L. Milch and others believe that the "law of volume," according to which those minerals which occupy minimum volume tend to develop, is counteracted by high temperature, which tends to bring about the opposite result. L. Milch therefore separates the crust into two zones, an upper in which the "volume law" controls, characterized by the development of hydrous minerals, and a lower zone in which temperature is the controlling factor and practically prevents the development of hydrous minerals. U. Grubenmann designates the transition between these two regions a third zone. The type minerals of the lower zone are pyroxene, garnet, biotite, lime plagioclase, potash feldspar, sillimanite, cordierite, olivine; those of the upper zone, zoisite, epidote, muscovite, albite, and chloritoid. Hornblende, quartz, tourmaline, staurolite, titanite, and rutile are common to both. Milch also believes that the "Kristalloblastic" texture of schists is determined by the crystallizing force of the contemporaneous minerals. Accordingly those minerals assume crystal form which have the densest aggregation of molecules, and preferably those crystal surfaces develop which have the closest spacing of molecules, particularly cleavage faces. Mineral parallelism is less due to mechanical plasticity than to solution and deposition according to the principle of Riecke. The following tables of U. Grubenmann show the relation of the three zones to the rocks which are characteristic of each.

CONTROLLING FACTORS OF EACH ZONE

	Temperature	Heat Toning	Hydrostatic Pressure	Stress	Predominant Effect of Pressure
Upper zone..	Moderate	–	Slight	Great	Mechanical
Middle zone.	Greater	– (–)	Greater	Very great	Chemical (Vol. law, Riecke prin.)
Deep zone...	Very great	–	Very great	Less	Chemical (show recrystallization with retention of form)

TABLE OF ROCKS OF EACH ZONE

Upper zone.	Quartz phyllite, sericite phyllite, lime phyllite, chloritoid schist, chlorite schist, talc schist, serpentine, epidote fels, and *topfstein.*
Middle zone.	Muscovite schist, muscovite-biotite schist, biotite schist, garnet-staurolite-actinolite schist, nephrite-glaucophane schist, mica gneiss, hornblende gneiss, garnet gneiss, epidote gneiss, marble, quartzite.
Deep zone.	Biotite gneiss, pyroxene gneiss, stillimanite-cordierite-garnet gneiss, granulite, garnet-mica schist, garnet fels, eclogite, jadeite, augite fels, marble, quartzite.

II. The various conceptions which assign the origin of crystalline schists to the agency of eruptive rocks can be grouped as:

1. Those which regard gneisses as primary unaltered eruptive rocks.
2. Those which ascribe the crystalline schists to the result of the metamorphic action of igneous rocks on sediments.

Crystallization of magmas under differential pressure or piezocrystallization (Weinschenk) and the deformation of igneous rocks while still charged with hot juvenile waters (Becke) have been suggested as processes which might explain the first.

Direct contact metamorphism, injections of the intrusive, mainly along parallel zones into the intruded rock, the action of mineralizers, and the absorption of the intruded by the intrusive rocks have been advanced by various writers as processes by which gneisses and schists have developed through the agency of igneous rocks. Michel Levy has pointed out that the alteration of sediments into schists and gneisses adjacent to contacts is not confined to recrystallization, but that there is a zone of impregnation which becomes regional with depth. Slow recrystallization has little effect on texture as contrasted with forcible injection of the intrusive and partial absorption of the older rock.

Occasionally, the contact between a slate and granite is marked by series of parallel injections of the granite into the slate, while masses of the slate have been submerged in the granite, and partially absorbed, giving rise to *schlieren*. Transferring this observation to large areas of schists, a part of them have been designated as "gneisses of injection" and still another as mixed rocks. Injection of materials is also connected with direct contact metamorphism, often resulting in recrystallization under pressure—piezo-crystallization. Weinschenk designates those schists whose development was conditioned by piezo-contact metamorphism as "alpine facies," and as normal facies those schists which have been developed through impregnation, injection, and resorption without the agency of pressure.

The conception that the action of mineralizers on sediments contributes to the origin of schists has been extended by Termier (1901, 1903) to explain the origin of lenses of peridotite, gabbro, or amphibolite concordantly imbedded in sediments. He regards them as materials which have risen from the deeps along bedding planes, somewhat like a large oil globule, and have locally converted the sediments into *roches vertes*.

Lepsius and Gürich have attached themselves to the French views more fully than other Germans. Lepsius with Barrois emphasizes the absorption of contacts by rising granite magmas; while Gürich has emphasized the action of mineralizers rising from magmas. Lepsius (1903) has maintained that the injection of a granite laccolite concordant with the parallel structures of the intruded rocks results in the intrusive forming granite gneiss, while with discordant injection it forms a massive granite. In both cases large quantities of the intruded rocks are absorbed, giving rise to variations in the composition of the intrusive. Gürich (1904), on the other hand, maintains that the material alteration of sediments and their conversion into gneisses is not due to a granite magma rising from the deeps, but is accomplished by the melting of compressed solid granites enveloped by sediments, on sudden release of pressure which results in absorption of the inclosing schists and alteration to gneiss.

Haug conceives that in geosynclinals, heat, pressure, and ascending mineralizers are sufficient to melt or partially convert sediments into granite magmas which consolidate into magmas on cooling. LeClere (1906) and P. Termier (1907), having similar views, hold that from the upper portions of the masses converted into granite magmas very little injection and impregnation of the surrounding rock results. The action of mineralizers in the upper portions has been just sufficient to convert the rocks into a granite magma.

E. STEIDTMANN

PATTON, H. B. "Topaz Bearing Rhyolite of the Thomas Range, Utah," *Bull. Geol. Soc. America*, XIX (1908), 177–92.

Discusses the environment and conditions of origin of these rather well-known topazes.

The topaz-bearing rock is a lithoidal rhyolite several hundred feet thick, the last of a series of five flows. Flow structure appears but locally and although the rock shows no solid spherulites, well-developed lithophysae are relatively abundant. These are lined with crystals of quartz, sanidine, garnet, specular hematite, topaz, and bixbyite. Topaz is also an important ingredient of the rock mass and the author describes the three varieties found.

1. Transparent topaz, which always occurs in small cavities in the rhyolite and was formed after the lithophysae were complete.

2. Rough opaque topaz, which abounds in the solid rock as well as in the cavities. The crystals are longer than the transparent variety, gray in color, with ends roughened as though subjected to the action of a solvent. The interior of these crystals is crowded with sharply defined quartz grains.

Forms transitional between groups 1 and 2 are found, from which it would appear that the two varieties are due simply to different conditions of growth.

3. Smooth opaque topaz, which is analogous to the rough opaque variety in habit, color, and occurrence. This variety has been found in but two places in this region, in each case having been developed in a fragment of rhyolite tuff which had been caught up in the rhyolite streams. These crystals are characterized by extreme smoothness of faces and the usually perfect terminations at either end.

The inclosing rock is quite similar in composition to the rhyolite in which it is imbedded. Thin sections show an aggregate of very irregular grains of quartz and of sanidine that vary in size from 0.1 mm. downward. The topaz crystals are perfectly normal and inclose countless minute and invariably sharply defined crystals of quartz which together make up about one-fourth the bulk. No other inclosures are found.

The writer concludes from his study of these topazes: (1) that the period of quartz crystallization was nearly the same as that of the topaz formation, and (2) that the agencies which caused the development of the topaz in the cavities also caused its development in the rock mass, in which space was provided partially by the complete removal of the feldspar and the recrystallization of the silica in definite crystals of quartz. This makes the opaque topazes not exactly foreign matter but an integral part of the rock.

HAROLD E. CULVER

ROGERS, AUSTIN F. "A New Specific Gravity Balance," *Science*, XXXIV (1911), 58–60.

This is a modification of the ordinary beam balance by which the specific gravity is read off directly from the beam. The graduations on the beam are the results of calculations for the various densities. The graduation is in units from 2 to 10, in tenths from 2 to 4, in fifths from 5 to 6, and in halves from 6 to 10. For such minerals as quartz, using a mass of two or three grams, the balance is accurate to about two units in the second decimal place.

HAROLD E. CULVER

ROGERS, G. S. "The Geology of the Cortlandt Series and Its Emery Deposits," *Annals, N.Y. Acad. Sci.*, XXI (1911), 11–86.

The Cortlandt series, best known perhaps through the classic researches of George H. Williams, covers about thirty square miles just southeast of Peekskill, N.Y., on the Hudson River. The following rocks, the distribution of which is shown on a colored map, constitute the principal types, although many of them grade into one another; granite, syenite, sodalite syenite, diorite, gabbro, hornblendite, biotite norite, augite norite, biotite augite norite, hornblende norite, biotite hornblende norite, olivine norite, quartz norite, pyroxenite, hornblende pyroxenite, olivine pyroxenite, biotite peridotite, and many dike rocks. Complete petrographic descriptions are given, together with seventeen new analyses. Surrounding the series is the Manhattan schist, associated with the Fordham gneiss and Inwood limestone, and xenoliths of these rocks are found in the series itself. The latter is therefore younger, but is older than the Triassic shales across the river, and is probably late Paleozoic. In general, no metamorphism is found in the series, but an original gneissoid structure is common; and from the evidence afforded therein, as well as from the distribution of the types, it is thought that the pyroxenite group was extruded first, followed closely by the norites, with the granites distinctly later. The position of the diorite group is problematical; it is possible that these types are the product of reactions between the igneous rocks and the surrounding metamorphics.

It is found that contact action between the igneous rocks and the limestone give rise to abnormal wernerite, tremolite, and grossularite mixtures; and similarly, contact with the aluminous schist produces a concentration of the biotite and magnetite of the latter, with the frequent formation of almandite, sillimanite, spinel, corundum, etc. The similarity of the phenomena exhibited at the emery mines with those shown on the borders is thought to indicate that the ore owes its origin to the inclusion and assimilation of schistose xenoliths, producing a local supersaturation of alumina which resulted in the deposition of corundum.

AUTHOR'S ABSTRACT

SCHWARTZ, E. H. L. "What Is a Metamorphic Rock?" *Geol. Mag.*, VIII (1911), 356–61.

In propounding this apparently academic query, the writer is actuated by the appearance of certain taxonomic inconsistencies in the latest treatise on metamorphism—Grubenmann's *Die kristallinen Schiefer*—which he believes would have been obviated by a more precise definition of the term. Van Hise defines a metamorphic rock as one that has been altered; but it is tacitly understood that a sediment does become metamorphic through induration, for example, nor will the development of pegmatitic structure remove a granite from the igneous class. Starting with the conception of the three zones of metamorphism, marked by increasing pressure and by the increasing molecular volumes of the rocks formed, Professor Schwartz notes the fact that the molecular volume of a true igneous rock will be still higher. Now solvent water is the agent active in forming the characteristic minerals and structures of igneous rocks, and this leads to an essential difference between them and the metamorphics. In the former the pressure is so great that the solid particles move freely into the solvent, allowing the chemical affinities of the molecules to satisfy themselves, while in the latter only the borders of the grains are rendered fluid, the chemical affinities are restricted, and the law of least molecular volume comes into play. Thus a metamorphic rock would be one in which the internal or molecular pressure had been less than the external or dynamic, so that certain peculiar minerals have resulted. Some of these, such as epidote, lose their crystalline form long before fusion, indicating a probable expansion of the molecule, under conditions which allow the chemical affinities full play. These minerals when found in a rock may therefore be accepted as criteria of its real nature.

This paper does not arrive at any very satisfactory conclusion, from a practical standpoint; but it must be remembered that it is primarily a protest against the want of definitiveness in the terms ordinarily employed, and that the author's recourse to physical chemistry is both tentative and reluctant.

G. S. ROGERS

WORKMAN, RACHEL. "Calcite as a Primary Constituent of Igneous Rocks," *Geol. Mag.*, VIII (May, 1911), 193–200. Pls. 2.

In this short paper is presented a very interesting description of the alkali igneous complex on the islands of Alnö and Langörsholmen, Sweden. The evidence seems conclusive that in this group of rocks calcite occurs as a primary constituent; in fact the two chief types of igneous rock are nephelite syenite and an almost pure calcite rock. Between these two extremes there are all gradations. No definite order of crystallization can be observed but the calcite is as a rule the last mineral to crystallize. The same minerals occur in the two types of rock except that cancrinite, which is abundant in the nephelite syenite, is absent where calcite is abundant.

The author calls attention to other areas of igneous rocks where calcite has been described as a primary constituent and discusses briefly the possible magmatic history of the mineral. Daly's theory of the absorption of limestone by a subalkali magma does not seem to be applicable here for lack of the necessary limestone. Högbom's conclusion is, that the calcite has crystallized from the magma in a manner exactly analogous to the other minerals.

E. R. LLOYD